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Noble County, Indiana

Pacific Northwest Environmental Res. Lab.

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April 1976

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

SYLVAN LAKE

NOBLE COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 341

WITH THE COOPERATION OF THE

INDIANA STATE BOARD OF HEALTH

AND THE

INDIANA NATIONAL GUARD

APRIL, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(c)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

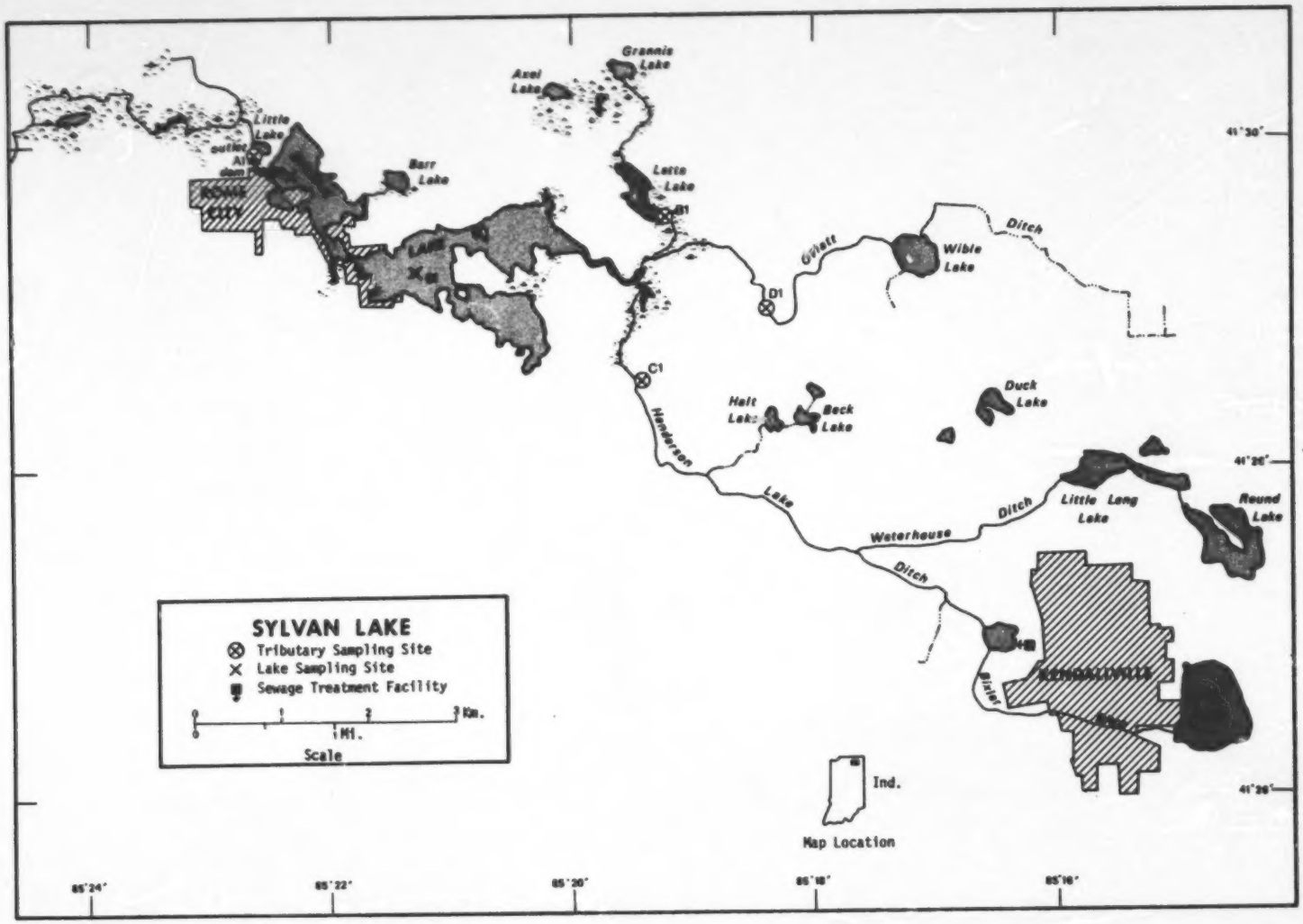
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


Grannis Lake
Axel Lake
Little Lake
outlet
Barr Lake
Latta Lake
D1
Gyhett
Wible Lake
Ditch
C1
Henderson
Halt Lake
Beck Lake
Duck Lake
Lake
Waterhouse
Ditch
Little Long Lake
Round Lake
Ditch
41°30'
41°28'
41°26'
SYLVAN LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 Km.
0 1 Mi.
Scale
Ind.
Map Location
85°24'
85°22'
85°20'
85°18'
85°16'

SYLVAN LAKE

STORET NO. 1848

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Sylvan Lake is eutrophic. It ranked eighteenth in overall trophic quality when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Twenty-five lakes had less median total phosphorus, 20 had less median dissolved phosphorus, one had less median inorganic nitrogen, 24 had less mean chlorophyll a, and 19 had greater mean Secchi disc transparency. Near-depletion of dissolved oxygen with depth occurred at station 2 in October.

Survey limnologists reported a heavy algal bloom in progress in August.

The trophic condition of Sylvan Lake appears to have improved somewhat since 1963-64 when it was studied by Wetzel (1966) and categorized as hypereutrophic and "...one of the most productive lakes in the temperate region of the world". It is likely that at least some of the improvement can be attributed to the Indiana phosphate detergent ban which became effective in January, 1972.

B. Rate-Limiting Nutrient:

Because of nutrient changes in the sample, the algal assay results are not considered indicative of conditions in the lake at

* See Appendix A.

the time the sample was taken (05/10/73). The lake data indicate that Sylvan Lake was nitrogen limited at all sampling times.

C. Nutrient Controllability:

1. Point sources--The point-source phosphorus contribution amounted to 44.3% of the total reaching Sylvan Lake during the sampling year. The City of Kendallville contributed 41.1%, and lakeshore septic tanks were estimated to have contributed 3.1% of the total.

The present phosphorus loading of 1.26 $g/m^2/yr$ is just over two times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). Complete removal of phosphorus at the Kendallville treatment plant would lower the overall loading to 0.74 $g/m^2/yr$. While this would still exceed the eutrophic loading of 0.62 $g/m^2/yr$, it is likely the reduced loading would result in persistent phosphorus limitation and improvement in the trophic condition of the lake.

2. Non-point sources--Over 55% of the total phosphorus input to Sylvan Lake was contributed by non-point sources during the sampling year. The Henderson Lake Ditch contributed 37.5%; Oviatt Ditch, 10.7%; and the Latta Lake outlet contributed 1.9% of the total. Ungaged tributaries were estimated to have contributed 4.3% of the total phosphorus input.

The phosphorus export rates of the Sylvan Lake tributaries com-

pare well with the rates of tributaries of nearby Witmer Lake*; i.e., Little Elkhart Creek (24 kg/km^2/yr) and Unnamed Stream C-1 (6 kg/km^2/yr).

* Working Paper No. 349.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 2.55 kilometers^2.
2. Mean depth: 4.3 meters.
3. Maximum depth: 11.0 meters.
4. Volume: 10.879 x 10^6 m^3.
5. Mean hydraulic retention time: 159 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Latta Lake outlet	6.7	0.06
Henderson Lake Ditch	51.5	0.48
Oviatt Ditch	17.1	0.16
Minor tributaries & immediate drainage -	9.6	0.09
Totals	84.9	0.79

2. Outlet -

Sylvan Lake outlet	87.5**	0.79**

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Sylvan Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the second visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 3.0 meters at station 1 and 5.5 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SYLVAN LAKE
STORET CODE 1848

PARAMETER	1ST SAMPLING (5/10/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/12/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	14.7 - 16.9	16.4	16.7	24.4 - 24.7	24.5	24.4	18.3 - 19.4	18.8	18.8
DISS OXY (MG/L)	9.2 - 11.9	11.1	11.6	4.8 - 7.4	6.2	5.7	0.2 - 10.0	5.6	6.8
CNDCTVY (MCROMO)	550. - 570.	557.	555.	530. - 555.	542.	534.	482. - 504.	490.	483.
PH (STAND UNITS)	8.3 - 8.8	8.6	8.7	8.1 - 8.6	8.3	8.4	7.8 - 9.0	8.4	8.6
TOT ALK (MG/L)	171. - 177.	174.	174.	158. - 163.	160.	161.	148. - 157.	152.	152.
TOT P (MG/L)	0.186 - 0.245	0.166	0.163	0.104 - 0.200	0.149	0.156	0.149 - 0.227	0.184	0.170
ORTHO P (MG/L)	0.013 - 0.026	0.017	0.016	0.010 - 0.021	0.015	0.015	0.032 - 0.130	0.076	0.063
NO2+NO3 (MG/L)	0.040 - 0.080	0.063	0.060	0.050 - 0.070	0.060	0.060	0.030 - 0.060	0.040	0.040
AMMONIA (MG/L)	0.040 - 0.110	0.063	0.055	0.060 - 0.180	0.088	0.075	0.070 - 0.830	0.286	0.100
KJEL N (MG/L)	1.100 - 1.500	1.333	1.400	2.200 - 2.600	2.367	2.350	2.500 - 2.800	2.620	2.600
INORG N (MG/L)	0.090 - 0.170	0.127	0.125	0.110 - 0.250	0.148	0.135	0.120 - 0.870	0.326	0.130
TOTAL N (MG/L)	1.140 - 1.560	1.397	1.470	2.250 - 2.670	2.427	2.400	2.530 - 2.840	2.660	2.640
CHLRPYL A (UG/L)	45.3 - 47.3	46.3	46.3	89.1 - 89.1	89.1	89.1	4.7 - 51.0	27.8	27.8
SECCHI (METERS)	0.6 - 0.9	0.7	0.7	0.5 - 0.8	0.7	0.7	0.9 - 0.9	0.9	0.9

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/10/73	1. Scenedesmus sp.	3,258
	2. Cryptomonas sp.	2,984
	3. Melosira sp.	1,887
	4. Flagellates	1,201
	5. Tetrastrum sp.	961
	Other genera	8,336
	Total	18,627
08/03/73	1. Oscillatoria sp.	5,216
	2. Aphanizomenon sp.	1,250
	3. Anabaena sp.	965
	4. Oocystis sp.	607
	5. Cryptomonas sp.	322
	Other genera	1,750
	Total	10,110
10/12/73	1. Oscillatoria sp.	6,612
	2. Scenedesmus sp.	918
	3. Melosira sp.	771
	4. Oocystis sp.	771
	5. Cryptomonas sp.	441
	Other genera	2,205
	Total	11,718

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/10/73	1	47.3
	2	45.3
08/03/73	1	89.1
	2	-
10/12/73	1	4.7
	2	51.0

C. Limiting Nutrient Study:

The algal assay results are not considered indicative of conditions in the lake at the time of sampling because of significant changes in nutrient concentrations in the sample between the field and the laboratory. The lake data indicate nitrogen limitation; the mean inorganic nitrogen/orthophosphorus ratios were 12/1 or less at all sampling stations and times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of February when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads at stations B-1 and D-1, in $kg/km^2/year$, and multiplying the means by the ZZ area in km^2.

The operator of the Kendallville wastewater treatment plant provided monthly effluent samples and corresponding flow data.

Estimated phosphorus loads were reduced by 50% to adjust for the phosphate detergent limitation in effect in Indiana since January, 1972.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Kendallville	7,000	tr. filter	4,935.6	Henderson Lake

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Latta Lake outlet	60	1.9
Henderson Lake Ditch	1,210	37.5
Oviatt Ditch	345	10.7
b. Minor tributaries & immediate drainage (non-point load) -	140	4.3
c. Known municipal STP's -		
Kendallville	1,325	41.1
d. Septic tanks** -	100	3.1
e. Known industrial - None	-	-
f. Direct precipitation*** -	45	1.4
Total	3,225	100.0

2. Outputs -

Sylvan Lake outlet	3,410

3. Net annual P loss - 185 kg.

* Marti, 1973.
** Estimate based on 700 lakeshore dwellings, two parks, and one camp; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Latta Lake outlet	3,665	3.2
Henderson Lake Ditch	50,010	44.0
Oviatt Ditch	27,445	24.1
b. Minor tributaries & immediate drainage (non-point load) -	10,330	9.1
c. Known municipal STP's -		
Kendallville	11,975	10.5
d. Septic tanks* -	7,600	6.7
e. Known industrial - None	-	-
f. Direct precipitation** -	2,755	2.4
Total	113,780	100.0

2. Outputs -

Sylvan Lake outlet	67,245

3. Net annual N accumulation - 46,535 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Latta Lake outlet	9	547
Henderson Lake Ditch	23	971
Oviatt Ditch	20	1,605

* Estimate based on 700 lakeshore dwellings, two parks, and one camp; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.26	loss*	44.6	18.2

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Sylvan Lake:	
"Dangerous" (eutrophic loading)	0.62
"Permissible" (oligotrophic loading)	0.31

* There was an apparent loss of phosphorus during the sampling year. This may have been due to solubilization of previously sedimented phosphorus, recharge with phosphorus-rich ground water, or unknown and unsampled point sources discharging directly to the lake or to one of the ungaged tributaries.

V. LITERATURE REVIEWED

Ketelle, Martha J., and Paul D. Uttormark, 1971. Problem lakes in the United States. EPA Water Poll. Contr. Res. Ser., Proj. #16010 EHR, Wash., DC.

Marti, James F., 1973. Treatment plant questionnaire (Kendallville STP). Kendallville.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Wetzel, Robert G., 1966. Variations in productivity of Goose and hypereutrophic Sylvan lakes, Indiana. Invest. Indiana Lakes & Streams, vol. VII, no. 5 (Oct.), pp. 147-184.

Winters, John, 1975. Personal communication (lake morphometry). IN Dept. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLOHA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATARACT LAKE	0.058	1.600	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.800	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITHER LAKE	0.035	0.980	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.480	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.867	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
.852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SOO-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITHER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1885	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1848 SYLVAN LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 87.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1848A1	87.5	1.08	1.26	1.78	1.67	1.08	0.82	0.50	0.18	0.17	0.18	0.43	0.78	0.82
1848B1	6.7	0.074	0.096	0.142	0.130	0.082	0.062	0.037	0.010	0.011	0.011	0.034	0.062	0.062
1848C1	51.5	0.620	0.739	1.051	0.983	0.634	0.484	0.292	0.102	0.096	0.102	0.252	0.467	0.483
1848D1	17.1	0.195	0.244	0.354	0.326	0.210	0.161	0.096	0.028	0.028	0.031	0.082	0.159	0.159
1848ZZ	9.8	0.110	0.139	0.204	0.190	0.119	0.093	0.054	0.016	0.016	0.017	0.048	0.093	0.091

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 87.5
SUM OF SUB-DRAINAGE AREAS = 85.2

TOTAL FLOW IN = 9.59
TOTAL FLOW OUT = 9.93

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1848A1	6	73	1.447	9	2.549				
	7	73	0.447	14	0.340				
	8	73	0.422	12	0.368				
	9	73	0.199	8	0.284				
	10	73	0.149	6	0.195				
	11	73	0.102	11	0.082				
	12	73	0.518	8	0.244				
	1	74	1.886	5	0.793				
	2	74	1.719	9	1.048	23	3.002		
	3	74	3.051	9	11.525	23	1.388		
	4	74	1.220	13	1.161				
	5	74	2.809	11	1.218				
1848B1	6	73	0.058	9	0.082				
	7	73	0.033	14	0.025				
	8	73	0.034	12	0.034				
	9	73	0.012	8	0.016				
	10	73	0.005	6	0.006				
	11	73	0.003	11	0.002				
	12	73	0.030						
	1	74	0.084	5	0.054				
	2	74	0.074	9	0.057	23	0.113		
	3	74	0.114	9	0.566				
	4	74	0.065						
	5	74	0.061	11	0.068				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1848 SYLVAN LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1848C1	6	73	1.413	9	2.435				
	7	73	0.416	14	0.340				
	8	73	0.345	12	0.311				
	9	73	0.141	8	0.193				
	10	73	0.050	6	0.068				
	11	73	0.031	11	0.021				
	12	73	0.360	8	0.122				
	1	74	1.376	5	0.651				
	2	74	1.277	9	0.651	23	1.982		
	3	74	1.662	23	0.793				
	4	74	0.617	13	0.510				
	5	74	0.847	11	0.850				
1848D1	6	73	0.150	9	0.210				
	7	73	0.086	14	0.065				
	8	73	0.087	12	0.085				
	9	73	0.032	8	0.042				
	10	73	0.012	6	0.016				
	11	73	0.008	11	0.006				
	12	73	0.077	8	0.031				
	1	74	0.217	5	0.139				
	2	74	0.191	9	0.147	23	0.283		
	3	74	0.294	23	0.181				
	4	74	0.169	13	0.190				
	5	74	0.158	11	0.173				
1848ZZ	6	73	0.085	9	0.119				
	7	73	0.048	14	0.037				
	8	73	0.049	12	0.051				
	9	73	0.018	8	0.024				
	10	73	0.007	6	0.009				
	11	73	0.005	11	0.003				
	12	73	0.043	8	0.018				
	1	74	0.123	5	0.079				
	2	74	0.108	9	0.082	23	0.164		
	3	74	0.167	9	0.821	23	0.102		
	4	74	0.096	13	0.108				
	5	74	0.089	11	0.099				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184801
41 29 11.0 085 21 20.0 3
SYLVAN LAKE
18113 INDIANA

003292

11EPALES 2111202
0013 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/10	16 30	0000	16.9		24	560	8.30	176	0.050	1.100	0.040	0.013
	16 30	0005	16.9	11.9		560	8.80	177	0.040	1.200	0.060	0.014
	16 30	0010	16.8	11.9		570	8.50	176	0.060	1.400	0.080	0.017
73/08/03	09 50	0000	24.7		21	555	8.60	161	0.080	2.600	0.070	0.012
	09 50	0005	24.6	7.4		555	8.40	163	0.070	2.200	0.070	0.017
	09 50	0010	24.6	7.3		555	8.40	160	0.060	2.400	0.050	0.021
73/10/12	09 15	0000	10.8	8.8	35	500	8.70	157	0.070	2.600	0.060	0.063
	09 15	0010	10.5	2.0		504	8.00	155	0.350	2.400	0.030	0.109

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/10	16 30	0000	0.123	47.3
	16 30	0005	0.245	
	16 30	0010	0.140	
73/08/03	09 50	0000	0.171	89.1
	09 50	0005	0.173	
	09 50	0010	0.200	
73/10/12	09 15	0000	0.170	4.7
	09 15	0010	0.227	

STORET RETRIEVAL DATE 76/03/30

184802
41 29 48.0 085 22 21.0 3
SYLVAN LAKE
18113 INDIANA

083292

11EPALES 2111202
0018 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/10	16 52	0000	16.6		34	550	8.80	171	0.050	1.500	0.060	0.026
	16 52	0005	16.3	11.4		550	8.80	171	0.070	1.400	0.080	0.017
	16 52	0015	14.7	9.2		550	8.60	172	0.110	1.400	0.060	0.016
73/08/03	10 30	0000	24.4	5.7	33	530	8.50	159	0.080	2.200	0.050	0.013
	10 30	0005	24.4	5.7		534	8.10	158	0.060	2.300	0.050	0.010
	10 30	0010	24.4			533						
	10 30	0012	24.4	4.8		534	8.10	161	0.180	2.500	0.070	0.018
73/10/12	09 40	0000	19.4	10.0	34	482	9.00	148	0.080	2.600	0.040	0.032
	09 40	0009	19.0	6.8		483	8.60	148	0.100	2.500	0.030	0.047
	09 40	0018	18.3	0.2		483	7.80	152	0.830	2.800	0.040	0.130

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/10	16 52	0000	0.106	45.3
	16 52	0005	0.186	
	16 52	0015	0.194	
73/08/03	10 30	0000	0.106	
	10 30	0005	0.104	
	10 30	0012	0.141	
73/10/12	09 40	0000	0.156	51.0
	09 40	0009	0.149	
	09 40	0018	0.220	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1848A1
41 29 55.0 085 22 40.0 4
SYLVAN-LITTLE LAKE CONNECTION
18 7.5 ALBION
O/SYLVAN LAKE 083291
BANK BELO DAM AT OUTLET
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	16 45		0.010K	2.100	0.028	0.014	0.095
73/07/14	10 15		0.030	1.470	0.010	0.010	0.050
73/08/12	11 00		0.012	2.300	0.013	0.021	0.095
73/09/08	09 00		0.033	2.000	0.154	0.007	0.100
73/10/06	10 00		0.044	2.940	0.140	0.032	0.170
73/11/11	09 35		0.075	2.300	0.399	0.068	0.200
73/12/08	09 10		0.120	0.600	0.224	0.108	0.210
74/01/05	10 40		0.250	1.100	0.336	0.156	0.185
74/02/09	10 00		2.200	1.200	0.300	0.070	0.115
74/02/23	14 10		1.800	2.000	0.345	0.070	0.130
74/03/09	08 35		1.340	1.900	0.250	0.020	0.170
74/03/23	09 50		1.340	1.900	0.020	0.015	0.120
74/04/13	09 30		1.090	1.700	0.040	0.010	0.030
74/05/11	10 10		0.127	2.200	0.133	0.020	0.150

STORET RETRIEVAL DATE 76/03/30

184881
41 29 30.0 085 19 16.0 4
SYLVAN-LATTA LAKE OUTLET
18 7.5 KENDALVILLE
T/LATTA LAKE OUTLET 083292
BOAT AT OUTLET OF LATTA LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/14	11 00		0.023	2.600	0.170	0.006	0.015
73/08/12	11 45		0.010K	0.880	0.022	0.009	0.015
73/09/08	09 50		0.010K	1.050	0.028	0.006	0.015
73/10/06	10 40		0.010K	0.910	0.026	0.005K	0.015
73/11/11	10 15		0.020	1.450	0.290	0.005K	0.015
74/01/05	10 25		0.650	0.800	0.148	0.012	0.030
74/02/09	09 40		1.100	0.800	0.055	0.010	0.065
74/02/23	13 40		0.504	1.100	0.135	0.005	0.015
74/03/09	08 25		0.352	1.600	0.145	0.015	0.090
74/05/11	09 40		0.192	0.600	0.050	0.005	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1848C1
41 28 30.0 085 19 30.0 4
HENDERSON LAKE DITCH
18 7.5 KENDALVILLE
1/SYLVAN LAKE 083292
SEC RD BRDG 2 MI E OF HWY 9
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	17	10	1.240	1.760	0.189	0.032	0.135
73/07/14	10	30	0.570	5.400	0.260	0.089	0.420
73/08/12	11	10	1.100	2.100	0.260	0.066	0.210
73/09/08	09	15	1.520	2.100	0.460	0.094	0.260
73/10/06	10	10	1.600	1.900	0.300	0.105	0.250
73/11/11	09	45	1.600	1.650	0.590	0.052	0.120
73/12/08	09	20	2.000	2.400	0.770	0.052	0.145
74/01/05	10	00	2.100	1.750	0.710	0.076	0.195
74/02/09	09	10	1.840	1.500	0.650	0.025	0.080
74/02/23	13	15	2.640	2.000	0.270	0.030	0.100
74/03/23	09	15	2.000	1.900	0.290	0.020	0.080
74/04/13	09	40	1.200	1.500	0.230	0.015	0.045
74/05/11	09	20	1.680	1.500	0.140	0.020	0.100

STORET RETRIEVAL DATE 76/03/30

1848D1
41 28 55.0 085 18 25.0 4
OVIATT DITCH
18 7.5 KENDALVILLE
T/SYLVAN LAKE 083292
SEC RD BRDG 2 MI W OF HWY 3
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	17 20		2.500	3.900	0.132	0.012	0.095
73/07/14	10 35		1.920	2.200	0.430	0.019	0.060
73/08/12	11 15		1.520	1.470	0.067	0.022	0.045
73/09/08	09 20		2.200	1.400	0.063	0.016	0.040
73/10/06	10 20		2.700	0.920	0.061	0.012	0.030
73/11/11	09 50		3.000	0.350	0.075	0.016	0.025
73/12/08	09 30		1.200	1.100	0.240	0.032	0.075
74/01/05	10 10		1.600	1.200	0.184	0.016	0.047
74/02/09	09 20		5.100	1.300	0.190	0.040	0.080
74/02/23	13 20		4.900	2.300	0.170	0.060	0.145
74/03/23	09 30		3.700	2.300	0.220	0.030	0.085
74/04/13	09 50		3.200	1.900	0.045	0.010	0.020
74/05/11	09 30		2.000	1.800	0.090	0.015	0.130

STORET RETRIEVAL DATE 76/03/30

1848CA TF1848CA P0070000
41 26 45.0 085 16 30.0 4
KENDALLVILLE
18 7.5 KENDALVILLE
T/SYLVAN LAKE 083292
HENDERSON LAKE DITCH
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/15	07 00								
CP(T)-									
73/06/15	22 00		3.500	4.300	0.550	0.165	0.580	1.300	1.500
73/07/12	07 00								
CP(T)-									
73/07/12	22 00		2.310	4.200	0.350	0.380	0.740	1.000	1.050
73/08/14	07 00								
CP(T)-									
73/08/14	23 00		1.100	5.100	0.350	0.590	1.450	0.900	1.000
73/09/18	07 00								
CP(T)-									
73/09/18	16 00		3.700	2.500	0.170	0.410	1.200	0.800	0.800
73/10/24	07 00								
CP(T)-									
73/10/24	23 00		1.740	5.800	0.310	0.126	0.730	0.900	0.900
73/11/27	07 00								
CP(T)-									
73/11/27	16 00		2.900	5.700	0.395	0.300	2.200	1.600	1.700
74/01/08	07 00								
CP(T)-									
74/01/08	16 00		2.600	6.400	0.180	0.220	0.830	1.200	1.200
74/01/15	19 00								
CP(T)-									
74/01/16	04 00		1.920	2.500		0.160	0.440	2.600	1.400
74/02/14	07 00								
CP(T)-									
74/02/14	16 00		1.840	5.600	0.630		0.370	1.400	1.600
74/04/25	07 00								
CP(T)-									
74/04/25	16 00		3.100	6.600	1.350	0.067	0.510	1.400	1.600
74/05/23									
74/06/25	07 00		3.300	2.800	0.480	0.180	0.630	1.800	1.600
CP(T)-									
74/06/25	16 00		1.760	3.400	0.330	0.075	0.180	2.000	1.700
74/07/23	07 00								
CP(T)-									
74/07/23	16 00		1.520	2.800	0.360	0.140	0.460	1.300	1.400